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SANFORD LAKE, MIDLAND COUNTY, MICHIGAN

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center, Corvallis, Oregon
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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT
ON
SANFORD LAKE
MIDLAND COUNTY
MICHIGAN

EPA REGION V

WORKING PAPER No. 210

WITH THE COOPERATION OF THE

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

AND THE

MICHIGAN NATIONAL GUARD

FEBRUARY, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Michigan Department of Natural Resources for professional involvement and to the Michigan National Guard for conducting the tributary sampling phase of the Survey.

A. Gene Gazlay, former Director, and David H. Jenkins, Acting Director, Michigan Department of Natural Resources; and Carlos Fetterolf, Chief Environmental Scientist, and Dennis Tierney, Aquatic Biologist, Bureau of Water Management, Department of Natural Resources, provided invaluable lake documentation and counsel during the course of the Survey. John Vogt, Chief of the Bureau of Environmental Health, Michigan Department of Public Health, and his staff were most helpful in identfying point sources and soliciting municipal participation in the Survey.

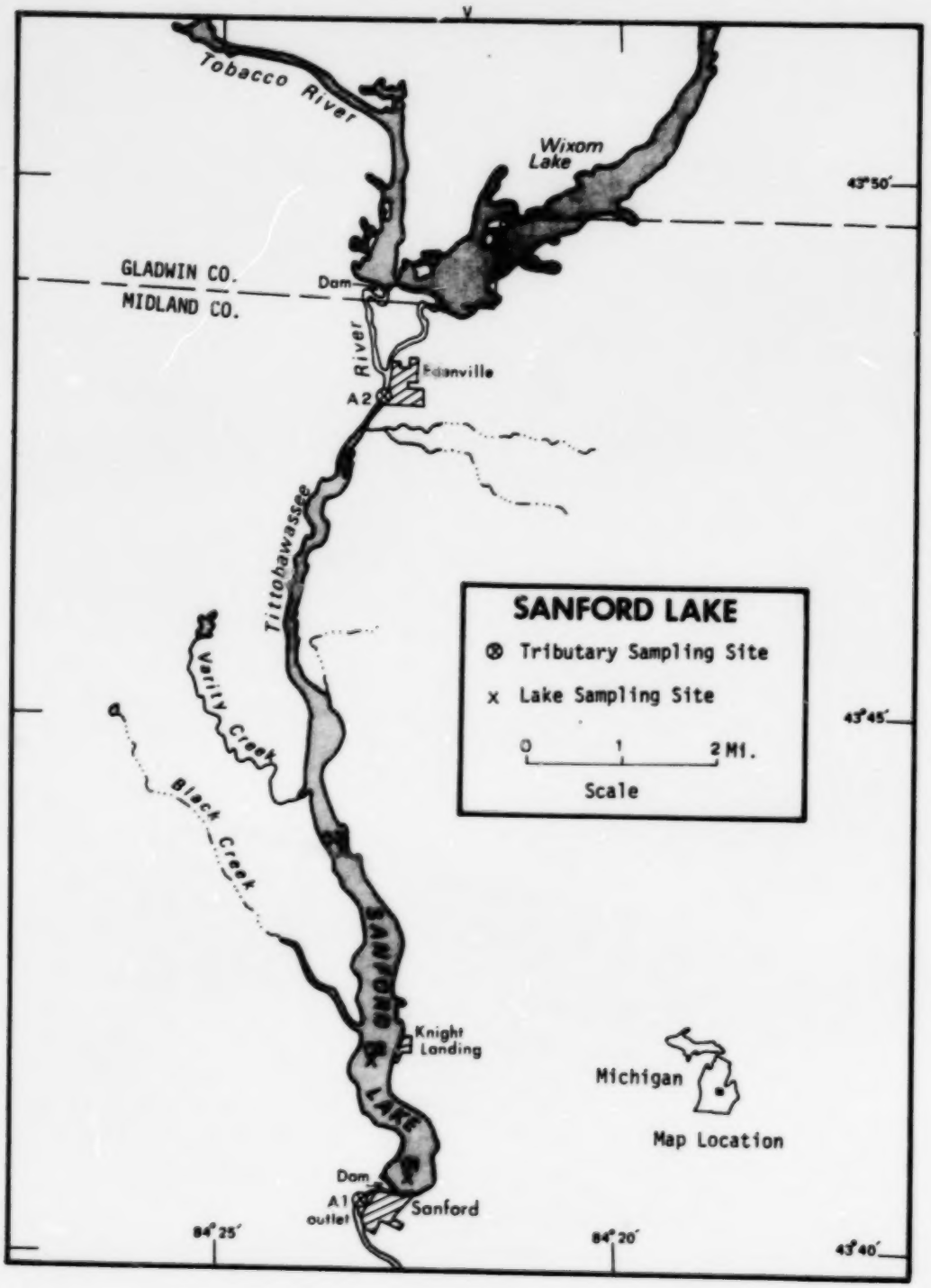
Major General Clarence A. Schnipke (Retired), then the Adjutant General of Michigan, and Project Officer Colonel Albert W. Lesky, who directed the volunteer efforts of the Michigan National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MICHIGAN

LAKE NAME	COUNTY
Allegan Res.	Allegan
Barton	Kalamazoo
Belleville	Wayne
Betsie	Benzie
Brighton	Livingston
Caro Res.	Tuscola
Charlevoix	Charlevoix
Chemung	Livingston
Constantine Res.	St. Joseph
Crystal	Montcalm
Deer	Marquette
Ford	Washtenaw
Fremont	Newago
Higgins	Roscommon
Holloway Res.	Genesee, Lapeer
Houghton	Roscommon
Jordon	Ionia, Barry
Kent	Oakland
Long	St. Joseph
Macatawa	Ottawa
Manistee	Manistee
Mona	Muskegon
Muskegon	Muskegon
Pentwater	Oceana
Pere Marquette	Mason
Portage	Houghton
Randall	Branch
Rogers Pond	Mecosta
Ross	Gladwin
St. Louis Res.	Gratiot
Sanford	Midland
Strawberry	Livingston
Thompson	Livingston
Thornapple	Barry
Union	Branch
White	Muskegon


Tobacco River
Wixom Lake
43°50'
GLADWIN CO.
MIDLAND CO.
Dam
Edenville
A2
Tittabawassee River
Verity Creek
Black Creek
SANFORD LAKE
Knight Landing
Dam
A1 outlet
Sanford
84°25'
84°20'
43°40'
43°45'
SANFORD LAKE
⊗ Tributary Sampling Site
x Lake Sampling Site
0 1 2 Mi.
Scale
Michigan
Map Location

SANFORD LAKE

STORET NO. 2674

I. CONCLUSIONS

A. Trophic Condition:

On the basis of Survey data and observations, it is concluded that Sanford Lake is eutrophic, although it appears to be in a better condition when only the data are considered. Of the 35 Michigan lakes sampled in the fall when essentially all were well-mixed, only four had less mean total and dissolved phosphorus, and only eight had less mean inorganic nitrogen*. However, Sanford Lake has a mean hydraulic retention time of only nine days, and relatively low nutrient levels are typical of such "flow-through" impoundments. Of the other parameters measured, 29 of the study lakes had greater Secchi disc transparency and 29 had less mean chlorophyll a*.

Survey limnologists reported an algal bloom in progress on September 20, 1972, and noted that rooted aquatic vegetation was common in the shallow parts of the lake.

B. Rate-Limiting Nutrient:

Because of a 50% loss of dissolved phosphorus in the algal assay sample from the time of collection to the beginning of the assay, the results are not indicative of conditions in the lake at the time of sampling.

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* See Appendix A.

The lake data indicate nitrogen limitation in June and September but phosphorus limitation in November.

C. Nutrient Controllability:

There are no known point sources directly impacting Sanford Lake. Nonetheless, during the sampling year, the lake received a total phosphorus load at a rate nearly twice that proposed by Vollenweider (in press) as "dangerous"; i.e., in excess of a eutrophic rate (see page 10). Now, Vollenweider's model probably is not applicable to a water body with such a short hydraulic retention time, and it is likely that the short retention time is suppressing the effects of the high nutrient loading rates.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 1,250 acres.
2. Mean depth: 9.8 feet.
3. Maximum depth: 20+ feet.
4. Volume: 12,250 acre feet.
5. Mean hydraulic retention time. 9 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
Tittabowassee River	1,012.0 mi^2	636.3 cfs
Minor tributaries & immediate drainage -	28.0 mi^2	19.6 cfs
Totals	1,040.0 mi^2	655.9 cfs

2. Outlet -

Tittabowassee River	1,042.0 mi^2**	655.9 cfs

C. Precipitation***:

1. Year of sampling: 31.1 inches.
2. Mean annual: 29.6 inches.

† MI Dept. Cons. lake inventory map (1951).
* Drainage areas are accurate within ±5%; mean daily flows for 74% of the sampling sites are accurate within ±25% and the remaining sites up to ±40%; and mean monthly flows, normalized mean monthly flows, and mean annual flows are slightly more accurate than mean daily flows.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods, 1972".

III. LAKE WATER QUALITY SUMMARY

Sanford Lake, an impoundment of the Tittabowassee River, was sampled four times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from two or more depths at each station (see map, page v). During each visit, a single depth-integrated (15 feet or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the second visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analyses. The maximum depths sampled were 12 feet at station 1, 20 feet at station 2, and 12 feet at station 3.

The results obtained are presented in full in Appendix C, and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix C.

A. Physical and chemical characteristics:

FALL VALUES

(11/14/72)

Parameter	Minimum	Mean	Median	Maximum
Temperature (Cent.)	4.7	4.9	4.9	5.1
Dissolved oxygen (mg/l)	10.2	11.3	11.3	12.4
Conductivity (μmhos)	410	423	420	435
pH (units)	8.0	8.0	8.0	8.1
Alkalinity (mg/l)	161	165	165	172
Total P (mg/l)	0.013	0.016	0.016	0.018
Dissolved P (mg/l)	0.007	0.008	0.008	0.009
NO_2 + NO_3 (mg/l)	0.140	0.240	0.260	0.280
Ammonia (mg/l)	0.060	0.067	0.070	0.080

ALL VALUES

Secchi disc (inches)	24	41	41	64

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Number per ml
09/20/72	1. Anabaena	1,772
	2. Dinobryon	1,483
	3. Flagellates	1,374
	4. Melosira	579
	5. Cyclotella	506
	Other genera	1,519
	Total	7,233
11/14/72	1. Fragilaria	909
	2. Asterionella	321
	3. Dinobryon	298
	4. Cryptomonas	68
	5. Synedra	48
	Other genera	126
	Total	1,770

* The June sample was lost in shipment.

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/14/72	01	14.7
	02	10.8
	03	16.8
09/17/72	01	10.6
	02	7.8
	03	-
09/20/72	01	39.4
	02	28.4
	03	16.3
11/14/72	01	3.4
	02	1.7
	03	1.4

C. Limiting Nutrient Study:

There was a loss of about 50% of the dissolved phosphorus in the algal assay sample between the time of collection (09/17/72) and the beginning of the assay. Consequently, the results are not indicative of conditions in the lake at the time of sampling.

The lake data indicate a narrow nitrogen limitation in June (N/P ratio = 13/1) and September (N/P = 12/1) and phosphorus limitation in November (N/P = 38/1).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Michigan National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of May, June, and July, when two samples were collected. Sampling began in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Michigan District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S) were estimated by using the nutrient loads, in lbs/mi^2/year, at station A-2 and multiplying by the ZZ area in mi^2.

The only known point source of nutrients upstream from Sanford Lake, and within the 25-mile limit of the Survey*, is the Village of Beaverton discharging to the Tobacco River. However, the Tobacco River arm of Wixom Reservoir intervenes and is a nutrient trap. Therefore, the Michigan Department of Natural Resources does not consider Beaverton to be a point source impacting Sanford Lake.

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* See Working Paper No. 1.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Tittabowassee River	42,260	96.7
b. Minor tributaries & immediate drainage (non-point load) -	1,180	2.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	80	0.2
e. Known industrial - None	-	-
f. Direct precipitation** -	200	0.4
Total	43,720	100.0

2. Outputs -

Lake outlet - Tittabowassee River 45,510

3. Net annual P loss - 1,790 pounds

* Estimated 120 shoreline dwellings; see Working Paper No. 1.
** See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Tittabowassee River	1,519,520	96.4
b. Minor tributaries & immediate drainage (non-point load) -	42,060	2.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	2,820	0.2
e. Known industrial - None	-	-
f. Direct precipitation** -	12,040	0.7
Total	1,576,440	100.0

2. Outputs -

Lake outlet - Tittabowassee River	1,569,040

3. Net annual N accumulation - 7,400 pounds

* Estimated 120 shoreline dwellings; see Working Paper No. 1.
** See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Tittabowassee River	42	1,502

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with very short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	35.0	loss*	1,261.2	5.9
grams/m^2/yr	3.92	-	141.4	0.7

Vollenweider loading rates for phosphorus (g/m^2/yr) based on mean depth and mean hydraulic retention time of Sanford Lake:

"Dangerous" (eutrophic rate)	2.00
"Permissible" (oligotrophic rate)	1.00

* The apparent loss of phosphorus during the sampling year is probably the result of too few samples in relation to the very short hydraulic retention time.

V. LITERATURE REVIEWED

Vollenweider, Richard A. (in press). Input-output models. Schweiz. Z. Hydrol.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	FALL VALUES: MEAN TOTAL P	FALL VALUES: MEAN DISS P	FALL VALUES: MEAN INORG N	ALL VALUES: 500-MEAN SEC	ALL VALUES: MEAN CHLORA	ALL VALUES: 15-MIN DO
26A0	HOLLOWAY RESERVOIR	0.062	0.043	1.461	439.375	10.676	9.200
26A1	CARO RESERVOIR	0.117	0.022	3.835	473.000	11.967	9.500
26A2	BOARDMAN HYDRO POND	0.006	0.005	0.358	363.500	1.267	6.600
2603	ALLEGAN LAKE	0.123	0.057	1.168	470.222	20.311	12.600
2606	BARTON LAKE	0.121	0.086	1.489	456.167	27.800	14.850
2609	BELLEVILLE LAKE	0.118	0.048	1.420	465.250	28.262	8.200
2610	BETSIE LAKE	0.025	0.008	0.273	461.667	4.567	7.400
2613	BRIGHTON LAKE	0.109	0.073	1.015	456.000	44.233	7.500
2617	LAKE CHARLEVOIX	0.007	0.006	0.230	351.250	3.008	9.240
2618	LAKE CHEMUNG	0.044	0.014	0.132	404.333	13.483	14.800
2621	CONSTANTINE RESERVOIR	0.027	0.008	0.910	456.167	39.317	7.500
2629	FORD LAKE	0.105	0.058	1.536	456.167	14.733	14.000
2631	FREMONT LAKE	0.372	0.342	1.406	441.667	28.500	14.800
2640	JORDAN LAKE	0.180	0.144	1.998	427.667	20.517	14.900
2643	KENT LAKE	0.040	0.015	0.417	455.000	33.944	13.000
2648	LAKE MACATAWA	0.197	0.120	2.358	477.600	25.600	12.200
2649	MANISTEE LAKE	0.018	0.010	0.304	451.333	6.317	11.380
2659	MUSKEGON LAKE	0.087	0.043	0.469	436.444	9.511	14.800
2665	PENTWATER LAKE	0.027	0.017	0.496	430.667	16.083	14.800
2671	RANDALL LAKE	0.246	0.183	0.818	457.333	27.217	8.020
2672	ROGERS POND	0.026	0.015	0.183	435.500	8.133	9.600
2673	ROSS RESERVOIR	0.034	0.021	0.460	465.333	10.383	8.200
2674	SANFORD LAKE	0.016	0.008	0.307	458.750	13.791	8.300
2683	THORNAPPLE LAKE	0.042	0.032	1.737	442.833	14.650	10.800
2685	UNION LAKE	0.083	0.064	1.252	455.500	15.667	8.200
2688	WHITE LAKE	0.027	0.019	0.367	417.778	9.211	13.400
2691	MONA LAKE	0.307	0.241	0.963	451.667	27.783	14.100
2692	LONG LAKE	0.163	0.148	0.749	418.400	10.067	13.600

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	FALL VALUES MEAN TOTAL P	FALL VALUES MEAN DISS P	FALL VALUES MEAN INORG N	ALL VALUES 500-MEAN SEC	ALL VALUES MEAN CHLOHA	ALL VALUES 15-MIN DU
2693	ST LOUIS RESERVOIR	0.134	0.093	1.227	462.667	5.583	8.420
2694	CRYSTAL LAKE	0.009	0.006	0.164	380.000	2.986	13.000
2695	HIGGINS LAKE	0.007	0.005	0.058	268.500	1.043	9.400
2696	HOUGHTON LAKE	0.018	0.008	0.136	420.833	9.217	8.200
2697	THOMPSON LAKE	0.043	0.029	0.436	407.889	11.967	14.800
2698	PERE MARQUETTE LAKE	0.032	0.024	0.346	448.667	11.833	8.600
2699	STRAWBERRY LAKE	0.069	0.050	0.567	419.800	11.117	13.600

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	FALL VALUES: MEAN TOTAL P	FALL VALUES: MEAN DISS P	FALL VALUES: MEAN INORG N	ALL VALUES: SEC-MEAN SEC	ALL VALUES: MEAN CHLOPA	ALL VALUES: 1S-MIN DO	INDEX NO
2640	HOLLOWAY RESERVOIR	46 (16)	43 (15)	17 (6)	57 (20)	60 (21)	63 (22)	286
2641	CARO RESERVOIR	29 (10)	54 (19)	0 (0)	3 (1)	49 (17)	54 (19)	189
2642	BUHOMAN HYDRO POND	97 (34)	97 (34)	69 (24)	91 (32)	94 (33)	97 (34)	545
2683	ALLEGAN LAKE	20 (7)	31 (11)	31 (11)	6 (2)	29 (10)	48 (14)	157
2686	BANTON LAKE	23 (8)	20 (7)	14 (5)	29 (9)	14 (5)	3 (1)	103
2689	BELLEVILLE LAKE	26 (9)	37 (13)	20 (7)	11 (4)	11 (4)	79 (26)	184
2610	BETSIE LAKE	77 (27)	77 (27)	80 (28)	17 (6)	86 (30)	94 (33)	431
2613	BRIGHTON LAKE	31 (11)	23 (8)	34 (12)	34 (12)	0 (0)	90 (31)	212
2617	LAKE CHARLEVOIX	91 (32)	91 (32)	83 (29)	94 (33)	89 (31)	60 (21)	508
2618	LAKE CHEMUNG	49 (17)	71 (25)	94 (33)	86 (30)	46 (16)	11 (2)	357
2621	CONSTANTINE RESERVOIR	71 (25)	83 (29)	40 (14)	29 (9)	3 (1)	90 (31)	316
2629	FORD [illegible]	34 (12)	29 (10)	11 (4)	29 (9)	37 (13)	23 (8)	163
2631	FREMONT LAKE	0 (0)	0 (0)	23 (8)	54 (19)	9 (3)	11 (2)	97
2640	JORDAN LAKE	11 (4)	11 (4)	6 (2)	69 (24)	26 (9)	0 (0)	123
2643	KENT LAKE	57 (20)	69 (24)	63 (22)	40 (14)	6 (2)	36 (12)	271
2648	LAKE MACATAWA	9 (3)	14 (5)	3 (1)	0 (0)	23 (8)	43 (15)	92
2649	MANISTEE LAKE	80 (28)	74 (26)	77 (27)	46 (16)	80 (28)	46 (16)	403
2659	MUSKEGON LAKE	37 (13)	40 (14)	54 (19)	60 (21)	69 (24)	11 (2)	271
2665	PENTWATER LAKE	69 (24)	63 (22)	51 (18)	66 (23)	31 (11)	11 (2)	291
2671	RANDALL LAKE	6 (2)	6 (2)	43 (15)	23 (8)	20 (7)	86 (30)	184
2672	ROGERS POND	74 (26)	66 (23)	86 (30)	63 (22)	77 (27)	51 (18)	417
2673	RUSS RESERVOIR	60 (21)	57 (20)	57 (20)	9 (3)	63 (22)	79 (26)	325
2674	SANFORD LAKE	86 (30)	80 (28)	74 (26)	20 (7)	43 (15)	71 (25)	374
2683	THORNAPPLE LAKE	54 (19)	46 (16)	9 (3)	51 (18)	40 (14)	49 (17)	249
2685	UNION LAKE	40 (14)	26 (9)	26 (9)	37 (13)	34 (12)	79 (26)	242
2688	WHITE LAKE	66 (23)	60 (21)	66 (23)	80 (28)	74 (26)	31 (11)	377
2691	MONA LAKE	3 (1)	3 (1)	37 (13)	43 (15)	17 (6)	20 (7)	123
2692	LONG LAKE	14 (5)	9 (3)	46 (16)	77 (27)	66 (23)	27 (9)	239

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	FALL VALUES: MEAN TOTAL P	FALL VALUES: MEAN DISS P	FALL VALUES: MEAN INORG N	ALL VALUES: 500-MEAN SEC	ALL VALUES: MEAN CHLORA	ALL VALUES: 15-MIN DO	INDEX NO
2693	ST LOUIS RESERVOIR	17 (6)	17 (6)	29 (10)	14 (5)	83 (29)	69 (24)	229
2694	CRYSTAL LAKE	89 (31)	89 (31)	89 (31)	89 (31)	91 (32)	36 (12)	483
2695	HIGGINS LAKE	94 (33)	94 (33)	97 (34)	97 (34)	97 (34)	57 (20)	536
2696	HOUGHTON LAKE	83 (29)	86 (30)	91 (32)	71 (25)	71 (25)	79 (26)	481
2697	THOMPSON LAKE	51 (18)	49 (17)	60 (21)	83 (29)	51 (18)	11 (2)	305
2698	PERE MARQUETTE LAKE	63 (22)	51 (18)	71 (25)	49 (17)	54 (19)	66 (23)	354
2699	STRAWBERRY LAKE	43 (15)	34 (12)	49 (17)	74 (26)	57 (20)	27 (9)	284

APPENDIX B

TRIBUTARY FLOW DATA

LAKE CODE 2674 SANFORD LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ MI) 1042.00

TRIBUTARY	SUB-DRAINAGE AREA(SQ MI)	NORMALIZED FLOWS(CFS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2674A1	1042.00	515.00	641.00	1571.00	1475.00	893.00	600.00	304.00	229.00	277.00	372.00	510.00	490.00	655.90
2674A2	1012.00	500.00	622.00	1524.00	1431.00	866.00	582.00	295.00	222.00	269.00	361.00	495.00	475.00	636.33
2674Z2	30.00	15.00	19.00	47.00	44.00	27.00	18.00	9.00	7.00	8.00	11.00	15.00	15.00	19.57

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 1042.00
SUM OF SUB-DRAINAGE AREAS = 1042.00
TOTAL FLOW IN = 7877.00
TOTAL FLOW OUT = 7877.00

MEAN MONTHLY FLOWS AND DAILY FLOWS(CFS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2674A1	10	72	606.00	29	850.00				
	11	72	798.00						
	12	72	573.00	2	440.00				
	1	73	1970.00	6	1750.00				
	2	73	768.00	2	1230.00				
	3	73	2720.00	3	768.00				
	4	73	1500.00	7	1753.00				
	5	73	1520.00	2	2347.00	10	2281.00		
	6	73	1080.00	4	2072.00	18	551.00		
	7	73	316.00	23	245.00	28	391.00		
	8	73	334.00	26	228.00				
	9	73	214.00	28	267.00				
2674A2	10	72	588.00	29	835.00				
	11	72	775.00						
	12	72	556.00	2	427.00				
	1	73	1910.00	6	1700.00				
	2	73	746.00	2	1190.00				
	3	73	2640.00	3	746.00				
	4	73	1454.00	7	1702.00				
	5	73	1474.00	2	2327.00	10	2215.00		
	6	73	1049.00	4	2012.00	18	535.00		
	7	73	307.00	23	238.00	28	380.00		
	8	73	324.00	26	221.00				
	9	73	208.00	28	260.00				
2674Z2	10	72	18.00						
	11	72	23.00						
	12	72	17.00						
	1	73	56.00						
	2	73	22.00						
	3	73	80.00						
	4	73	44.00						
	5	73	41.00						
	6	73	32.00						
	7	73	9.00						
	8	73	10.00						
	9	73	6.30						

APPENDIX C

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/02/04

267401
43 41 00.0 084 22 30.0
SANFORD LAKE
26 MICHIGAN

11EPALES
5

2111202
0015 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/14	15 55	0000	21.4	8.0	64	390	8.15	138	0.090	0.050	0.022	0.014
	15 55	0010	20.5	7.9		390	8.10	138	0.100	0.160	0.017	0.010
72/09/17	15 22	0000			24	328	8.88	143	0.040	0.060	0.022	0.009
	15 22	0004	21.4	12.2		330	8.80	136	0.040	0.050	0.041	0.014
	15 22	0012	20.4	9.3		340	8.55	136	0.050	0.060	0.022	0.010
72/09/20	11 00	0000			40	420	8.15	131	0.030	0.060	0.021	0.011
	11 00	0004	20.2	8.2		420	8.10	130	0.040	0.060	0.033	0.012
	11 00	0012	20.1	7.7		420	8.03	131	0.030	0.060	0.021	0.010
72/11/14	16 30	0000			44	420	8.00	161	0.280	0.070	0.018	0.008
	16 30	0004	5.1	11.2		420	8.10	161	0.280	0.060	0.018	0.008
	16 30	0011	5.1	11.2		420	8.10	161	0.280	0.060	0.013	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/14	15 55	0000	14.7J
72/09/17	15 22	0000	10.6J
72/09/20	11 00	0000	39.4J
72/11/14	16 30	0000	3.4J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 73/02/14

267402
43 42 00.0 084 23 00.0
SANFORD LAKE
26 MICHIGAN

11EPALES
5

2111202
0014 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/14	16 25	0000	20.8	8.4	51	340	8.05	143	0.090	0.060	0.014	0.012
	16 25	0010	20.1	7.2		390	8.15	143	0.080	0.080	0.022	0.014
72/09/17	15 40	0000			34	340	8.00	130	0.060	0.070	0.015	0.010
	15 40	0004	21.0	9.3		340	8.30	129	0.060	0.060	0.019	0.011
	15 40	0010	20.4	9.0		340	8.30	131	0.080	0.100	0.012	0.009
72/09/20	10 40	0000			32	425	7.95	134	0.050	0.070	0.023	0.011
	10 40	0004	20.0	7.9		420	7.95	132	0.050	0.060	0.027	0.013
	10 40	0015	19.9	7.3		420	7.95	132	0.060	0.080	0.023	0.010
	10 40	0020	19.9	6.7		420	7.85	131	0.060	0.070	0.022	0.010
72/11/14	16 15	0000			41	410	8.00	163	0.260	0.070	0.014	0.009
	16 15	0004	4.9	11.4		420	8.00	165	0.260	0.080	0.018	0.007
	16 15	0015	4.9	10.2		430	8.00	167	0.260	0.070	0.016	0.008
	16 15	0020	4.9	12.4		420	8.00	167	0.260	0.070	0.016	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/14	16 25	0000	10.4J
72/09/17	15 40	0000	7.8J
72/09/20	10 40	0000	28.4J
72/11/14	16 15	0000	1.7J

J VALUE KNOWN TO BE IN ERROR

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STORET RETRIEVAL DATE 75/02/04

267403
43 43 42.0 084 23 30.0
SANFORD LAKE
26 MICHIGAN

11EPALES 2111202
3 0007 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/14	16 55	0000	20.8	8.6	39	420	8.10	155	0.050	0.050	0.018	0.009
72/09/17	16 05	0000			42	360	8.30	144	0.110	0.070	0.016	0.010
	16 05	0004	21.3	8.4		360	8.30	144	0.110	0.060	0.014	0.009
	16 05	0009	21.3	8.3		360	8.27	141	0.120	0.070	0.017	0.010
72/09/20	10 20	0000			40	440	7.90	144	0.100	0.070	0.021	0.011
	10 20	0004	20.1	7.7		430	7.90	142	0.100	0.060	0.025	0.011
	10 20	0012	20.0	8.4		449	7.85	143	0.090	0.060	0.023	0.012
72/11/14	16 00	0000			44	430	8.00	172	0.140	0.060	0.015	0.007
	16 00	0004	4.7	11.4		435	8.00	172	0.140	0.060	0.014	0.009

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/14	16 55	0000	16.8J
72/09/20	10 20	0000	16.3J
72/11/14	16 00	0000	1.4J

J VALUE KNOWN TO BE IN ERROR

APPENDIX D

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/02/04

26/4A1 LS26/4A1
43 40 30.0 084 23 30.0
111TAHOMASSEE RIVER
CO 15 SANFORD
07SANFORD LAKE (RESVR)
05 10 0000
11EPALES 2111204
+ 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/12/02	06 00		0.270	0.630	0.015	0.005K	0.021
73/01/06	04 00		0.460	0.570	0.042	0.010	0.028
73/02/02	16 30		0.380	2.100	0.135	0.013	0.040
73/03/03	09 30		0.290	0.840	0.063	0.012	0.025
73/04/07	09 00		0.273	2.300	0.072	0.009	0.030
73/05/02	15 10		0.340	1.150	0.023	0.016	0.055
73/05/10	17 40		0.176	0.720	0.012	0.005K	0.035
73/06/04	14 00		0.336	0.660	0.094	0.020	0.055
73/06/18	09 20		0.011	1.400	0.070	0.006	0.035
73/07/23	16 40		0.010K	0.570	0.020	0.005K	0.035
73/07/28	09 00		0.014	0.760	0.014	0.005K	0.045
73/08/28	09 00		0.010K	0.520	0.012	0.005K	0.030
73/09/28	09 00		0.010K	0.540	0.039	0.008	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/04

2674A2 LS2674A2
43 46 00.0 084 23 30.0
TITTABOWASSEE RIVER
26 MIDLAND CO
1/SANFORD LAKE (RESVR)
CURTIS RD BRDG
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/29	09	25	0.220	1.400	0.160	0.009	0.031
72/12/02	09	30	0.238	1.000	0.046	0.007	0.020
73/01/06	09	30	0.460	1.130	0.132	0.017	0.038
73/02/02	17	00	0.330	1.260	0.096	0.013	0.035
73/03/03	10	00	0.340	0.560	0.072	0.012	0.025
73/04/07	09	30	0.231	0.960	0.048	0.006	0.025
73/05/02	16	35	0.340	1.700	0.031	0.017	0.070
73/05/10	17	30	1.440	0.600	0.024	0.005K	0.030
73/06/04	12	00	0.357	0.690	0.060	0.019	0.045
73/06/18	09	05	0.011	0.830	0.033	0.007	0.035
73/07/23	17	10	0.010K	1.050	0.020	0.005K	0.040
73/07/28	09	30	0.012	0.750	0.012	0.005K	0.025
73/08/28	09	30	0.010K	0.480	0.007	0.005K	0.025
73/09/28	09	30	0.010K	0.480	0.060	0.008	0.025

K VALUE KNOWN TO BE
LESS THAN INDICATED